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Building the Analytic Foundation for DIS Tool: A Planning Tool for Users of Distributed Interactive Simulation (DIS)

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BDM Federal, Inc.

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BUILDING THE ANALYTIC FOUNDATION FOR DIS TOOL: A PLANNING TOOL FOR USERS OF DISTRIBUTED INTERACTIVE SIMULATION (DIS)

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Distributed Interactive Simulation (DIS) provides a potentially cost-effective environment for collective, combined arms, and joint training and combat developments testing. DIS costs are kept low, in part, by using computer generated forces (CGF) to serve as the opposition force and as part of the friendly force. To realize the potential benefits of DIS it is critical to have measures of performance for manned units, and the behavior of the CGF must be sensitive to the same variables that influence the behavior of manned units. Both performance measurement and CGF behavior have been based heavily on physical attributes of weapon systems and battlefield environments with little or no attention to perceptual and cognitive variables. This report describes the broad concept for automated DIS Taxonomy of On and Off-line (DIS TOOL) performance variables to support the needs of a wide range of users including combat developers, training developers, CGF developers, materiel developers, and operational testers and evaluators.

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Building the Analytic Foundation for DIS TOOL:
A Planning Tool for Users of Distributed Interactive Simulation (DIS)

I. Introduction

The press of technology and a reduction in resources has led the U.S. Army to develop a technology-based training strategy. The premier example of this strategy is the distributed interactive simulation (DIS) environment. The DIS environment, an outgrowth of the DARPA sponsored Simulation Networking (SIMNET) technology development effort, is currently being used to support combined arms training as well as combat development efforts. DIS provides an effective and cost efficient means for supporting both training and combat developments in part through the use of computer generated forces (CGF) to serve as either opposition forces (OPFOR) or adjacent or supporting elements of friendly forces.

The Army Science Board (ASB) Summer Study on Army Simulation Strategy (1991) acknowledged the power of the technology push on training systems by arguing that the Army aggressively adopt the electronic battlefield for training, with emphasis on achieving a combined arms capability. The ASB concluded that the use of simulation is on the increase and serves a vital role in preparing the Army for the 21st century. The increased use and importance of simulation was attributed to constrained funding, test range and training space limitations, the high cost of hardware demonstrations of new systems, and new simulation capabilities. DIS capabilities afford a wide-range of opportunities to address the needs of various Army communities interested in combat development, system acquisition, test and evaluation, and training.

Those using simulation capabilities such as DIS are doing so in an attempt to keep pace with a rapid evolution of electronic technologies. These technologies are being configured into devices and weapon systems intended to enhance combat performance; however, they introduce new system development, training, and test and evaluation requirements which must be addressed. Evidence of the trend towards using DIS to meet the Army's changing requirements is provided by the Army's Modernization Plan for Training (Department of the Army, 1993b) which calls for a move toward greater use of training aids, devices, simulators and simulations (TADSS). Key aspects of the modernization plan call for technology-based elements, including a system which provides a common, consistent and accredited simulated representation of the combined force battlefield (DIS). According to the modernization plan, "DIS enhances warfighting capabilities; the fielding of superior weapons systems; and, early development of doctrine and tactics, force development, rapid prototyping, and the evaluation of tech base concepts..."

A requirement generated by the use of DIS is the specification of performance variables which address not only the outcomes of performance, the courses of action taken, and the conditions under which the mission was performed but also the cognitive and perceptual variables of the participants that influence performance. Currently, there is little understanding of the relationship between human cognitive and perceptual variables and combat performance. To date, human perceptual and cognitive domains have not been programmed into DIS for CGF modeling, nor classified into a taxonomy of human performance variables relevant to combat. Generally

speaking, most attention has been focused on the modeling of physical attributes and characteristics in the creation of the DIS environments. Thus, this paper addresses the need for a DIS TOOL to facilitate user access to a taxonomy of human performance for perceptual, cognitive, and motor processes which occur under combat situations. DIS TOOL will support the identification of measures of performance (MOPs) and measures of effectiveness (MOEs) that will satisfy the anticipated needs of a wide variety of Army communities; especially those interested in training development, combat development, test and evaluation, and CGF development.

Performance measures are at the heart of empirically deriving the value and benefit of new systems and training development efforts. Therefore, performance assessment with reliable and valid measures should be a chief concern of any DIS user. Assessments and their measures provide the basis for studies of effectiveness and efficiency that allow for informed trade-off decisions. The derivation of the performance measures in a simulation environment is a complex undertaking and must account for multidimensional performance parameters. The development of DIS TOOL is critical to users of DIS technology who recognize the need to go beyond the domain of physical variables (e.g., distance travelled) to study how behaviors that are primarily perceptual or cognitive in nature relate to combat performance.

II. Background

Faced with the changing battlefield dynamics of the next century and the advent of the information age of technology, soldiers will be waging an information war. DIS will play a pivotal role in helping the Army speed the acquisition cycle of emerging warfighting technologies by supporting their design, development, testing, and personnel training through rapid prototyping. To ensure that the Army is prepared to win the information war, Army communities must account for the relationship of perceptual and cognitive processes to battlefield behavior by exploiting current DIS features and developing important enhancements such as DIS TOOL.

Current DIS features include:

- Vertical and horizontal network distribution for collective training and long-haul networking.
- Selective functional fidelity which permits the prioritization of functional requirements
- Virtual prototyping which supports the use of modeling and simulation to assist in the system acquisition process.
- Real-time, man-in-the-loop simulation.

- Seamless simulation which permits networked interaction between synthetic and real-world environments.

- Varying threat environments supported by semi-automated forces.

- Variety of terrain data bases to support contingency missions.

These DIS features can be used to develop new assessment strategies and innovative efforts directed at planned activities such as constructive simulation exercises; doctrine and tactics development; command and unit training (including combined-arms training); and operational planning and rehearsal. However, DIS users need an instrument which will guide their planning efforts and ensure that the underlying perceptual and cognitive processes that drive battlefield performance will be adequately assessed. To this end, DIS TOOL will play an important role in aiding combat developers, training developers, CGF designers and test and evaluation communities. DIS TOOL's primary contribution will be the identification of behavioral components of performance. DIS TOOL will support accurate unit performance assessment by providing a taxonomy of human performance variables that encompasses perceptual and cognitive processes. Thus, DIS users who have an interest in mission performance which extends beyond measurement approaches aimed only at physical behaviors stand to benefit substantially from the development of DIS TOOL.

Simulation offers a cost-effective strategy for providing Army communities a variety of conditions under which to conduct research and/or training. However, as digitization of the battlefield evolves, followed by the information war, there is a growing need for a greater range of performance measures suitable for a variety of purposes related to developing and assessing training, equipment, or CGFs that will adequately support new battlefield warfighting strategies. A logical extension of pioneering work done by the Army Research Institute (ARI), DIS TOOL will help fill the current performance measurement void.

In a number of ways, ARI has laid the foundation for measuring unit mission performance and for recognizing the need to extend traditional measurement approaches to accommodate anticipated changes in training requirements and technologies. First, ARI conducted research focused on unit performance at the National Training Center (NTC) which resulted in a systems model specifying both outcome and process measurement systems (Lewman, et al., 1988). Next, this work was built upon to create the Unit Performance Assessment System (UPAS) which supports unit performance measurement and training feedback in DIS environments by allowing for the measurement of physical system variables, such as position of systems, firing activities, casualties suffered, and ammunition expenditures (Meliza, Bessemer, Burnside, & Schlechter (1992). Additional advances in performance measurement have been made by the ARI Fort Knox Field Unit as part of the Combat Vehicle Command and Control (CVCC) program. This effort included both automated data capture similar to UPAS, as well as observational data focused on command, control, and communication (C). The CVCC research (e.g., Leibrecht, et al., 1993) utilized innovative approaches to performance measurement by addressing how the situational awareness of the participants was impacted by automated C devices. Thus, the development of performance measurement capabilities such as UPAS and the research associated with the CVCC program have laid the foundation for the development of DIS TOOL which will address the full complement of cognitive and perceptual variables that play a role in combat performance.

Clearly, simulation-based training and assessment methods require the appropriate measurement and planning tools to support effective use of DIS environments. A major proponent of DIS technology that will benefit substantially from the development of DIS TOOL is the Army Battle Labs. Proposed by Gen. Franks, battle labs will focus on emerging technologies and changes in tactics and doctrine. The six battle labs will conduct experimentation using DIS capabilities to support the determination of requirements driven by the future battlefield (Department of the Army, 1993a). These battle labs will provide different Army communities the opportunity to integrate their various knowledge areas with industry, resulting in a powerful research and development network. The research areas of each of the six battle labs are listed in Table 1 and reflect the Army's clear need to reach beyond traditional measurement strategies that primarily focus on the physical dimension of performance.

Table 1
Battle Lab Research Areas

BATTLE COMMAND (FORT LEAVENWORTH,KS)
- C2 movement ability - Combat Service Support battlefield automation - Horizontal integration of digitized information
EARLY ENTRY, LETHALITY, AND SURVIVABILITY (FORT MONROE,VA)
- Lethality, survivability, mobility,and sustainability of Early Entry Force - Intelligence Preparation of the Battlefield - Armored force deployability
DEPTH AND SIMULTANEOUS ATTACK (FORT SILL, OK)
- Accuracy of attack systems - Enemy force at maximum depth - Near-real-time intelligence and targeting information - Intelligence and electronic warfare with attack systems in near-real-time to optimize targeting
DISMOUNTED BATTLE SPACE (FORT BENNING, GA)
- Night fighting for combined arms, combat support, and combat services support - Target acquisition across combined arms forces - Soldier survivability through signature reduction, individual sensors, and lightening the load - Lethality of weapons for direct and indirect fire
MOUNTED BATTLE SPACE (FORT KNOX, KY)
- Situational awareness and target hand-off - Survivability of the mounted force - Armored threats in all conditions with increased probability of success
COMBAT SERVICE SUPPORT (FORT LEE, VA)
- Soldier and system sustainment - Asset visibility for all classes of supply - Logistics communication and automation

DIS TOOL will be a performance measurement asset to Army communities such as the battle labs by assisting in the following activities:

- Identifying and characterizing tasks and behaviors that can be performed or simulated based on Critical Combat Functions (CCFs), echelon, and METT-T conditions;
- Guiding users in specifying performance requirements for specific applications;
- Identifying appropriate variables to measure performance of relevant tasks and behaviors;
- Allowing users to select appropriate variables and retrieve previously used measures and define new measures;
- Allowing users to identify gaps in behaviors that can be simulated or measured in existing systems.

In sum, DIS TOOL will support the identification of TADSS-based measures which have a high utility for various Army communities. DIS TOOL will save users from identifying and cataloguing all potential measures which would be an extremely large and resource intensive task. By providing an operational framework of performance measurement which covers a comprehensive domain of multidimensional variables, DIS TOOL will allow users to plan DIS exercises using select measures which have doctrinal soundness and compatibility with operational/field measures.

III. DIS TOOL Overview

A. Vision of DIS TOOL. Army development communities must now do more (use DIS) with less (shrinking budgets, personnel downsizing) and achieve higher standards (satisfy requirements for emerging doctrine, new threats, and complex equipment). The development of a taxonomy of human performance variables spanning cognitive and perceptual dimensions is an important first step towards the development of tools that can assist different Army communities in the optimal utilization of synthetic environments like DIS. A major obstacle that will be overcome by DIS TOOL relates to the fact that most DIS research has focused on individual performance and individual attributes. The DIS TOOL taxonomy focuses primarily on collective training and thus is concerned with unit as well as individual performance. At present, definitive research has not been performed that maps individual characteristics to groups or vise versa. DIS TOOL will make a significant contribution to understanding this issue in that it will provide a taxonomy which spans individual soldier through crew to battalion performance.

DIS TOOL will provide trainers, combat developers, test and evaluation personnel, equipment designers, software engineers, and modelers with a powerful tool to use in planning doctrinally sound electronic exercises. The completed taxonomy will demonstrate a direct linkage to the doctrinal sources used by soldiers as they train. To accomplish this, a key challenge was

locating a doctrinally sound analytic structure which provided the appropriate level of detail. That is, the analytic structure had to be sufficiently detailed to support performance measurement while also providing a high organizational structure to sustain focus and be clear about inter-relations between tasks such as synchronization and coordination. The CCFs will provide a useful framework in this respect. The CCFs are at a level of aggregation between tasks and the Battlefield Operating Systems (BOS) contained within the Blueprint of the Battlefield (Department of the Army, 1991). Further, they provide direct linkages across echelons in terms of task dependencies. Finally, the CCFs specify key players, procedures, and information flows. As such, they form the most complete specification of battlefield functionality at battalion and below developed to date. The CCFs are described in detail in Mullen (in preparation).

B. DIS TOOL's linkage to CCFs. DIS-TOOL is intended to provide the user with the information needed to construct exercises and measurement approaches that address the concerns of the user. The structure of DIS-TOOL is planned to be highly flexible and relates to a number of kinds of higher organization used in the military setting for tasks and activities. This type of system is needed to address the concerns of the various Army communities. To incorporate the needs of these communities, a general organizational framework for military combat activities must be used. As a trainer's tool, DIS-TOOL should relate to these or other types of organization used in the completion of military combat activities. For example, past DIS exercises have used BOSs as an organizational structure for addressing key research issues. While BOSs have been useful they are also at an extremely broad level, which makes addressing specific research questions difficult. The complexity of the interrelationships that occur in combat situations has lead to the development of CCFs. The CCFs are compatible with the BOSs but break down the combat operations process into smaller units. This allows for the examination of more specific relationships and the synchronization of different functions. Thus, the CCFs contribute a rich structure from which to develop and address research questions which may be aimed at a variety of issues relevant to doctrine and tactics.

CCFs provide a suitable framework for DIS TOOL by examining the complex interlocking activities that occur during a combat situation and providing a level of description that is intermediate in focus. These features allow the CCFs to play a critical role in building a bridge between BOSs and Army Mission Training Plans (AMTPs). In addition, CCFs provide a way to incorporate the doctrinal sources such as Army Training and Evaluation Programs (ARTEP) as well as AMTPs with the functional requirements of combat power. Using CCFs as the organizational framework for DIS TOOL has a number of practical applications. First, training that is based on functional requirements will be highly useful because it will tend to focus on a broader range of requirements necessary for successful task completion. Second, training that can be linked to outcome measures as well as lessons learned demonstrates the utility of the training involved.

C. CCF structure. As previously mentioned, CCFs can be interrelated. For instance, CCF 15 (coordinate, synchronize, and integrate fire support), is related to CCFs 6 (fire support and maneuver), 16/17 (take active/passive air defense measures) and 25 (provide operations security). These interrelationships are important to consider in that they point the direction toward desirable outcomes that affect the battle. As an example, a training developer can refer to the task analysis for CCFs 16/17 (Jarrett, in progress) to find that CCFs 16/17 link to CCF 15 in terms of the tasks associated with the integration of fires needed to attack enemy

helicopter positions. In addition to specifying interrelationships between CCFs, the task analysis will also provide DIS users with a description of how each CCF relates to a particular BOS; specify the outcomes and purposes of the CCF; provide a task flow by task force battle phase plan, prepare and execute diagrams; list key participants by task; list key inputs; and specify a task list summary and full task lists for the planning, preparing, and execution of missions. This information is structured in such a way that specific components (e.g., interrelationships between CCFs) may be considered in isolation. Thus, the CCF structure enables an individual to consider a number of different information categories without becoming mired in the detailed tasks of any particular CCF.

DIS TOOL, in conjunction with the CCFs, will provide a means to organize the wide range of information that is available to the user. By breaking down the battlefield into functional units, tasks associated with those functional units will become clear. Table 2 shows how each of the 39 CCFs are embedded within a particular BOS and illustrates the complementary nature of the Blueprint of the Battlefield (BOB) to the CCFs. CCF descriptions presented below are taken from Mullen and Kastanek (in progress).

Intelligence BOS

These CCFs include all functions related to intelligence planning, collection, processing, and dissemination. Conduct Intelligence Planning (CCF 1) primarily focuses on the Intelligence Preparation of the Battlefield (IPB) and includes reconnaissance and surveillance plan, threat templates, and terrain and weather analyses. Collect Information (CCF 2) focuses on gathering information from various sources and also includes managing and processing these activities. Process (CCF 3) and dissemination (CCF 4) of intelligence involve the conversion of intelligence into a usable format and the transmission of this information to appropriate members of the combined arms team. Together, these CCFs cover all activities related to intelligence tasks. These CCFs provide the activities relevant to acquiring, analyzing, and using knowledge of the enemy, weather, and terrain to give the commander with the necessary inputs in planning, preparing, and executing combat operations. An important aspect of these CCFs is that they are continuous throughout all phases of the battle.

Maneuver BOS

The CCFs in this group involve the use of direct fire weapons, platforms, and systems through movement, fire, and maneuver to achieve a position of advantage in relation to enemy ground forces. Two CCFs are grouped here: conduct tactical movement (CCF 5) and engage enemy with direct fire and maneuver (CCF 6). These CCFs are designed to cover the positioning of direct fire weapons systems as well as using direct fire and/or close combat to destroy or make the enemy withdraw. These CCFs include tasks involved in the dissemination of OPORDs, preparation and rehearsal of battle plans and maneuver, protection and control of terrain, and consolidation and reorganization tasks.

Table 2
Index of Critical Combat Functions by BOS

INTELLIGENCE	(1) Conduct Intelligence Planning
	(2) Collect Information
	(3) Process Information
	(4) Disseminate Intelligence
MANEUVER	(5) Tactical Movement
	(6) Engage Enemy with Direct Fire and Maneuver
AIR DEFENSE	(16) Active Air Defense Measures
	(17) Passive Air Defense Measures
FIRE SUPPORT	(7) Mortars
	(8) Artillery
	(9) Close Air Support
	(10) Conduct Electronic Collection and Jamming
	(11) Conduct Battlefield PsyOps
	(12) Employ Chemical Weapons
	(13) Counter Target Acquisition Systems
	(14) Naval Gunfire (Deleted)
	(15) Fire Support Integration
MOBILITY and SURVIVABILITY	(21) Overcome Obstacles
	(22) Enhance Movement
	(23) Provide Countermobility
	(24) Enhance Physical Protection
	(25) Operations Security
	(26) Deception
	(27) Decontamination
COMMAND and CONTROL	(18) Plan for Combat Operations
	(19) Direct and Lead Unit During Preparation Phase of Battle
	(20) Direct and Lead Unit in Execution of Battle
COMBAT SERVICE SUPPORT	(28) Provide Transport Services
	(29) Supply
	(30) Personnel
	(31) Maintenance
	(32) Health Services
	(33) Battlefield Casualty and Excavation
	(34) Enemy POW Operations
	(35) Law and Order Operations
	(36) Civil Affairs Operations
	(37) Provide Sustainment Engineering
	(38) Evacuate Noncombatants
	(39) Provide Field Services

Fire Support BOS

The CCFs in this group involve the collective, coordinated, and synchronized use of target acquisition data, indirect fire weapons, armed aircraft, and other means against ground targets in support of maneuver force operations and to achieve commander's intent and scheme of maneuver. These CCFs include the use of mortars, field artillery, close air support, chemical weapons, and naval gunfire. A number of these CCFs involve actions taken to disrupt enemy command, control, and communications or combat operations such as electronic collection and jamming and the conduct of battlefield psyops. Most involve the employment of different types of weapons systems and the coordination of those weapons systems.

Air Defense BOS

The CCFs related to this BOS involve taking active and passive air defense measures. These actions are designed to stop or reduce the effectiveness of attack by hostile forces. Active air defense measures include the use of air defense artillery, maneuver unit weapon systems and the coordination of these systems. Passive air defense measures include dispersion, cover and concealment, and deception.

Command and Control BOS

These CCFs involve how the maneuver commander exercises authority and direction over organic and assigned combat power in the accomplishment of the mission. They frequently involve the direction and leading in a battle. The focus is on the planning of combat operations and providing direction and leadership in preparation and execution for the battle.

Mobility and Survivability BOS

These CCFs involve how a force engages in maneuver, counter maneuver, and deception measures, and enhances protection and security. A variety of tactics may be employed here designed to accomplish different goals in overcoming obstacles or enhancing movement. These may involve overcoming obstacles, facilitating movement for other units, conducting deception operations, or enhancing physical protection and security.

Combat Service Support BOS

The majority of CCFs fall into this category and entail the variety of operations that are necessary to sustain sources and include logistics, personnel services, and health services. These are activities necessary to maintain the operations of the force. These may be logistical in nature such as providing transport services or supply operations, and maintaining weapons systems and equipment. Personnel services may include financial services, legal, and public affairs. Health services include treating and evacuating casualties.

CCFs are useful because they are divided into small units so that the interrelationships of different functions may be examined. Therefore, it is logical to think that certain groups of CCFs will be critical during different parts of the battle and that users of the DIS system will want to examine the interrelationships of several CCFs in constructing an exercise. Thus, coordination of direct fire may be a particularly important issue and may be measured in terms of fratricide incidents, or the dimensions of timeliness and accuracy.

Key Objectives and Technical Approach

The development of DIS TOOL is focused on two primary technical objectives as identified below:

1. To design and execute procedures for developing a taxonomy of human performance variables, including perceptual and cognitive variables, that may be used to identify significant dimensions that need to be measured to enable accurate unit performance assessment in the DIS environment. The taxonomy will be designed for use as a planning tool that would assist combat developers, training developers, CGF designers, and support test and evaluation in the DIS environment.

2. To demonstrate the utility of the product in controlling CGF behavior and analyzing unit performance. This objective requires showing how the contents of the taxonomy can be used to identify refinements and enhance the value of training feedback and testing within the DIS environment.

The final DIS TOOL will meld the product of these two objectives, resulting in a comprehensive planning tool for a wide variety of DIS users. The initial development effort described here began with an independent but parallel and related approach to meeting the two objectives, with the intention of building a comprehensive taxonomic framework that would satisfy both objectives. Figure 1 illustrates the relationship between the development efforts which to date have been primarily analytic in focus. The current effort has laid the ground work for satisfying Objective 1 and is described in this report while the approach to satisfying Objective 2 may be found in Weaver and Mullen (in preparation). The planned approach utilized for the accomplishment of Objective 1 was evolutionary in nature. This approach allows for continuous refinement and input so that the resulting product incorporates as much innovation and creative thinking as possible given the time and resource constraints. While the DIS TOOL taxonomy requires further development, testing, modification, and alliance with Objective 2, a strong foundation for supporting its continued development has been built. The remainder of this section will present an overview of the technical approach used to achieve Objective 1 while Chapter 4 will further describe the tasks remaining to be accomplished for DIS TOOL in order to complete this effort and the final taxonomy.

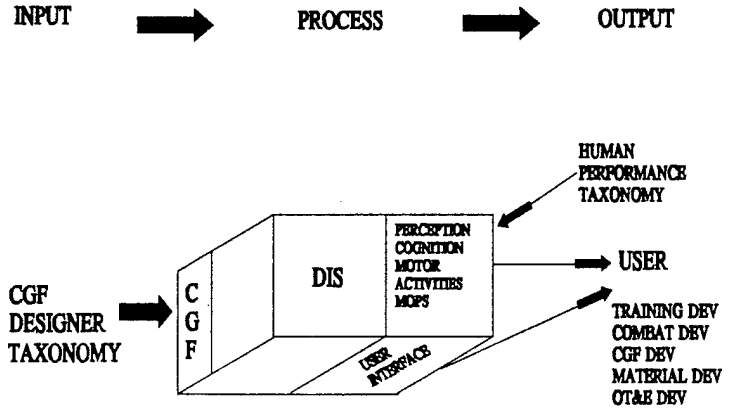

Figure 1 Relationship Between DIS TOOL development efforts.

The technical approach to taxonomy development was based on two principal tenets. The first is that, if the DIS TOOL is to serve multiple users, then each user group must be represented throughout the development process. Thus, an advocate for

each community was appointed to represent the views of that community. This is illustrated in Figure 2, where five principal communities have been represented. In the performance of the advocacy role, each individual was to act as a filter viewing the tasks and elements of the taxonomy from the perspective of the purposes appropriate to that community. The second tenet is structural in nature and suggests that the human performance characteristics and the influences of the environmental/ contextual variables are focused on subtasks (products/outcomes), processes, and actions embedded in the higher order structure. The technical approach was also shaped by specific milestones involved in the initial development and completion of the taxonomy. These milestones are highlighted in Table 3 and described in BDM Federal (1993). The current status of major milestones is reviewed in Chapter 4.

Figure 2. DIS TOOL User Communities.

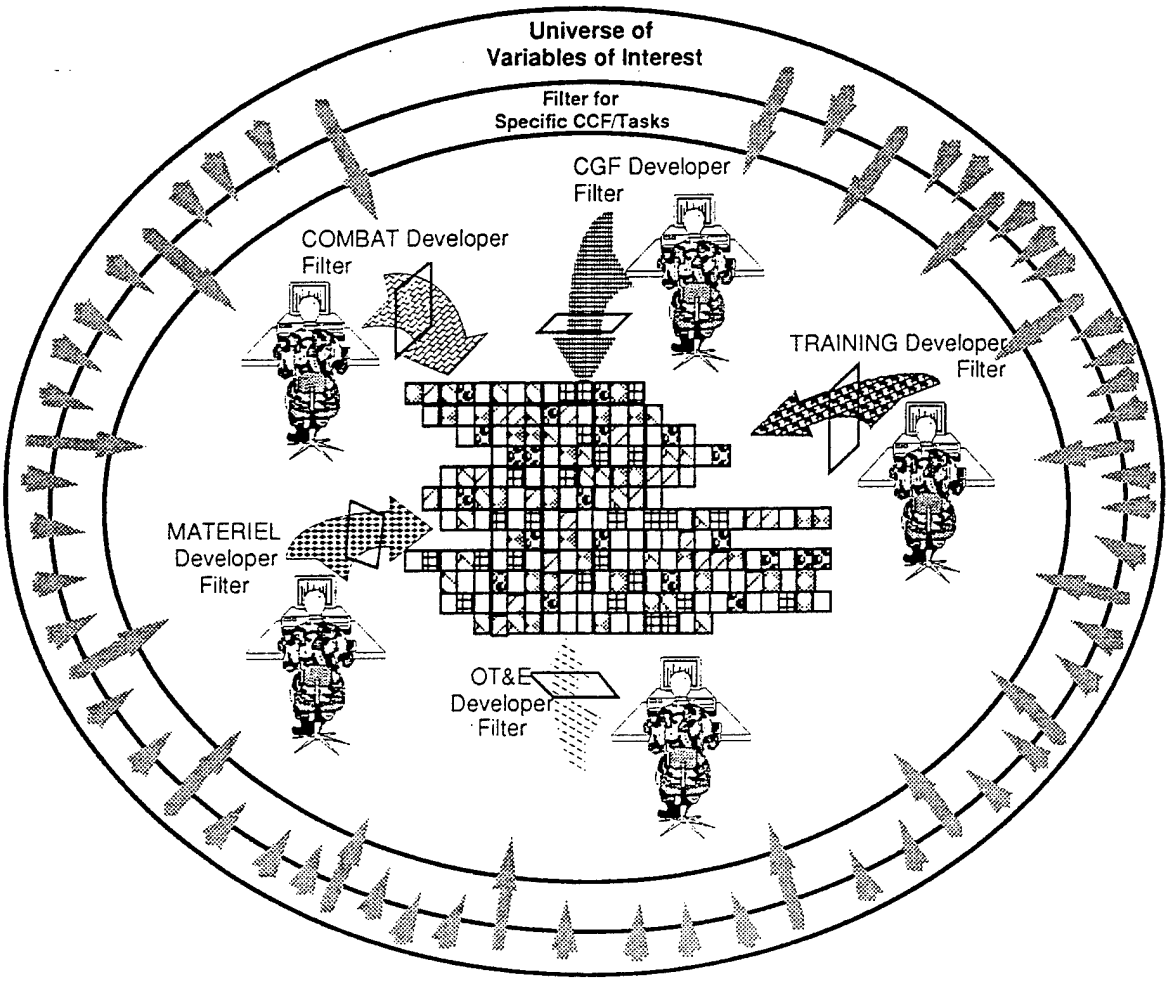

Table 3
DIS TOOL Milestones

PREPARE COMPREHENSIVE PERFORMANCE PLAN

- Conduct Kickoff Meeting
- Prepare Draft Plan
- Incorporate Feedback

DEVELOP A TAXONOMY OF COGNITIVE AND PERCEPTUAL VARIABLES FOR THE DIS ENVIRONMENT

- Specify Boundary Conditions
- Specify Taxonomy
- Specify Variable Definitions
- Plan for Taxonomy Completion

DEVELOP DIS TOOL AND ITS APPLICATION TO CGF AND UNIT PERFORMANCE ASSESSMENT

- Develop Software representation of the taxonomy
- Demonstrate external validity of the taxonomy

Taxonomy Description

Any taxonomic effort must consider several important factors in its development. This is particularly true for a system that is designed to be a multipurpose tool in planning DIS exercises.

The first consideration is the purpose that the taxonomy must serve. The taxonomy's purpose must be clearly and explicitly defined. Second, a taxonomy should use the appropriate subject matter and organizational structure for the subject matter. This type of information may consist of observed behaviors, hypothesized intervening processes, required abilities, or measured responses. Third, a method for classification must be developed which consists of rules which determine class inclusion or exclusion. Each of these considerations should be taken into account when constructing and evaluating a taxonomy. To this end, the taxonomy proposed here is designed to deal with the processes as well as overt measurements. This taxonomy is seen as related to other elements such as performance dimensions, categories of measures, indicators, and utility/value. This provides the opportunity for the user to "enter" the taxonomy from a number of different perspectives, based upon the questions being asked.

The purpose of the DIS TOOL taxonomy is to allow an individual, regardless of the Army community to which they belong, to make use of available information in such a way that will optimize the planning of DIS exercises for a variety of users. This suggests that the taxonomy must be flexible in nature so that individuals with varying needs will be able to easily use it. In

other words, people will want to examine problems from a number of different perspectives and the taxonomic structure should take this into account. For example, a trainer may want to examine the processes (e.g. perceptual, cognitive, or motor) relevant to effective command and control performance. On the other hand, a combat developer may be interested in the accuracy of a new weapon system as modeled in the DIS environment. Thus, the training developer would most likely enter the taxonomy at a different location than the combat developer.

Figure 3 presents the general higher order structure of the taxonomy. The highest level is mission, followed by Global METT-T, CCF, phase, and task. Echelon is not separately represented as it is included in the CCF structure. These five levels are consistent with doctrine and allow for the use of decompositions similar to those accomplished during the study of the CCFs. Below the task level, the intervention of human characteristics and the factors of METT-T are reflected. For example the cues that elicit specific behaviors come from the local METT-T. The introduction of the terms "processes" and "actions" reflect our belief that the taxonomy needs to specify human performance at a level of granularity finer than the subtask. Thus each subtask would be analyzed in terms of the inherent processes and actions required of the human participant(s) in order for the subtask to be performed to standard.

The lowest levels of the taxonomy are measure categories and user-defined measures (indicators). The advocates described above will play an important role at these levels and at operationally defining variables for each performance dimension. For example, one measure category of the performance dimension, situational awareness, is accuracy. A potential indicator for this measure category is the accuracy of SPOT report locations. Advocates will provide input as to other potential indicators and indicator definitions. It is our view that the measures are a function of purpose and hence need to be defined by each DIS user for each specific purpose. The advocates will establish the parameters for their community and a methodology for elaboration of measures appropriate for their community.

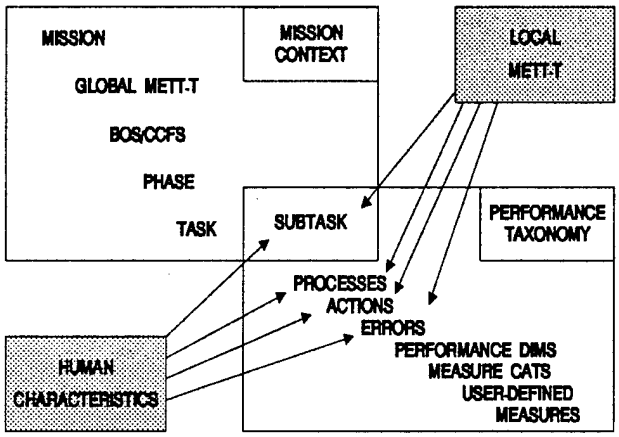

Figure 3. DIS TOOL Human Performance Taxonomy Framework.

The taxonomy is based on the relationship between perceptual, cognitive, and motor processes which defines the constructs that underlie activities. The taxonomy assumes that processes relate to observable activities and behaviors and that these behaviors may be viewed as relating to performance errors which target the sources of nonoptimal performance. In turn, performance dimensions are related to categories of measures which classify operational measures of the performance dimensions. Thus, "time to detect BLUFOR" is an indicator which reflects the measure category timeliness and the performance dimension detection. Finally, indicators represent a specific measure of performance. Each dimension of the taxonomy is further described below and a strawman of the DIS TOOL taxonomy may be found in the appendix.

Processes. Processes give a broad overview of the underlying variables that are relevant to unit performance. In turn, these processes relate to observable behaviors such as the synchronization of tactical movement and the employment of mortars. The processes providing the framework for this taxonomy are perceptual, cognitive, and motor in nature. In turn, these processes may be broken down into specific elements. For example, an important aspect of perceptual processes is "collect battlefield information" which includes processes relevant to monitoring and recognizing important battlefield stimuli. Cognitive processes include those steps involved in conducting analyses and planning, as well as battlefield management and communication. Finally, motor processes involve maneuver, engagement of enemy, and the control of terrain. These processes identify the aggregate dynamics at work in the combat environment and can be conceptualized at the individual or unit level.

Activities. From the standpoint of the user, processes may be of general interest but they may not address the questions being asked. Rather, it may be more useful to examine activities and behaviors, the overt manifestations that are recorded since behaviors are often seen as linking directly with performance. To ensure that unit level performance is measured, the activities identified for the taxonomy are mostly collective in nature and are linked to key tasks associated with the CCFs. For example, conducting an air watch is an important component of CCF 17 (take passive air defense measures) and fits under the global characterization of collecting battlefield information. Table 4 shows each of the processes linked to a set of relevant battlefield activities that support the measurement of unit-level mission performance.

Table 4
DIS TOOL Processes Linked to Battlefield Activities

PERCEPTUAL	**Collecting Battlefield Information:** Conduct air/ground watch, receive early warning signals, focus/visualize the battlefield.
COGNITIVE	**Conduct Analysis and Pre-Planning:** Evaluate/integrate/develop/prepare information, plan for combat operations, direct and lead unit during preparation for the battle.
	Conduct Final Planning and Battle Management: Update information, rehearse, air watch, deceive, synchronize tactical operations, manage fire control and distribution, integrate direct fire with maneuver, manage air space, consolidate and reorganize.
	Send, Receive, Disseminate Information: Send/receive/disseminate intelligence and battlefield reports, manage information.
MOTOR	**Maneuver, Engage Enemy, Control Terrain:** Control system input; navigate; employ direct fire, mortars, field artillery and close air support; cover and conceal; disperse.

Error Sources. Error sources are intended to serve as a guide to future DIS TOOL users wanting to expand the taxonomy within a given process. The error sources identified for perceptual processes are sensitivity and focus. These are the domains under which performance errors are anticipated for perceptual processes and should provide developers with important cues as to where performance decrements occur and the types of indicators which will target those decrements. For instance, a training developer may have additional "collect battlefield information" activities that he/she desires to train. While this might require the development of new performance measures, the error sources tell the developer the most likely origin of nonoptimal behavior. In the case of collecting battlefield information, the error sources indicate that soldiers are most likely to err in terms of failing to detect, incorrectly detecting, and failing to share attention optimally between various sources of input.

Performance Dimensions. DIS users usually have a general idea of the types of performance variables that he or she may want to examine such as "sensitivity to detection", etc. Performance dimensions provide DIS users with broad categories of potential performance assessment dimensions which can be measured in a variety of ways. For instance, the performance dimensions for collecting battlefield information are detection and situational awareness. These were identified as common issues for many of the DIS users at the Fort Knox Mounted Warfare Test Bed (MWTB) facility. Both detection and situational awareness are vulnerable to sensitivity and focus errors as a result of collecting battlefield information. As the taxonomy is expanded, it is likely that additional performance dimensions will be identified. Community advocates and developers should ensure that new performance dimensions link to key components of the taxonomy such as error sources and activities for a particular process.

Measure Categories. Measure categories classify outputs related to measures of performance including behaviors associated with timeliness, completeness, accuracy, and operational perspective. Table 5 shows each category and its definition. These categories provide a framework for categorizing performance in terms of specific criteria such as accuracy of performance. An important aspect of these measure categories is that they are constant across performance dimensions. This consistency provides DIS users with a "common denominator" with which to frame research findings for test issues that span across different processes.

Table 5
DIS TOOL Measure Categories Defined

ACCURACY	The extent to which misperception of a stimulus event or information content result in an incorrect response.
TIMELINESS	The extent to which reaction time to a stimulus is optimal with regard to METT-T, SALUTE (size, activity, location, unit, time, equipment and 5 Ws+H (who, what, when, where, why and how)).
FREQUENCY	The number of times a particular behavior occurs.
OPERATIONAL PERSPECTIVE	The extent to which information is accurately placed within the context of friendly/enemy force operations, areas of interest; time/phasing duration of the operation; missions of higher, lower or adjacent units; unit contingency plans in place or in development; friendly capabilities related to operations; enemy capabilities related to operations.

Indicators. Indicators, such as "time to detect OPFOR", refer to specific measures of performance which are grouped by the broader categories described above. The majority of the performance measures identified in the taxonomy have been successfully operationalized within a DIS environment. The current framework provides a fairly comprehensive mechanism for categorizing measures of performance and is flexible enough to allow for the inclusion of new performance measures as requirements are identified. Developers and community advocates will play a heavy role in the identification of additional performance measures for each measure category.

Value/Utility. Measures must demonstrate utility, that is they must show their value to training, etc. by their ability to predict success. Thus, while not specified on the initial taxonomy, the final taxonomy will evolve to eventually identify measures that have demonstrated predictive validity in the past.

Utility of Taxonomy

The DIS TOOL taxonomy will relate CCFs to unit level processes, etc. which can then be translated into measures of performance. For instance, a trainer could relate CCFs to a DIS effort by specifying exercises that incorporate or require the incorporation of several CCFs simultaneously. Thus, the DIS exercise could examine the joint influence of several CCFs and suggest ways to measure their influence.

The DIS TOOL taxonomy will show utility as it relates to the needs of the Army and provide information regarding the perceptual and cognitive variables deemed important for performance measurement. In a general sense, processes are related to activities and behaviors, which in turn are related to sources of error, performance dimensions, categories of measures, indicators, and utility/value. Thus, these different structures are linked to each other in a way which provides the user a mechanism for "tracing" through the taxonomy (from processes to indicators, for example). The importance of this taxonomy is that these structures link to each other and relate general performance dimensions and processes to indicators. Further, the DIS TOOL taxonomy specifies important links between various aspects of human performance in a way not yet provided to DIS users.

IV. Future Development of DIS TOOL

As noted earlier, the technical approach for DIS TOOL has been established but more work is needed to develop a functioning and tested tool. The completion of several tasks characterize the progress to date. First, a performance plan was written specifying a complete methodological approach for the initial effort (see BDM Federal, 1993). Second, community advocates for combat development, CGF development, training development, materiel development and test and evaluation development were appointed to represent their respective communities. Third, the development of a DIS TOOL taxonomy designed to reflect processes and behaviors as well as related performance dimensions, measures, and indicators was begun and is described in this report. Finally, a companion report describes the initial development of a decision taxonomy based upon simulation modeling techniques that emulate human reasoning and decision making (Weaver & Mullen, in preparation). These two reports, reflect the initial separate approaches to achieving the technical objectives of the DIS TOOL effort. The largest task remaining is the marrying of the two approaches, resulting in a software implementation which will demonstrate the utility of DIS TOOL in satisfying both technical objectives: (a) To design and execute procedures for developing a taxonomy of human performance variables, including perceptual and cognitive, that may be used to identify significant dimensions that need to be measured to enable accurate unit performance assessment in the DIS environment; and (b) to demonstrate the utility of the product in controlling CGF behavior and analyzing unit performance. The union of these two objectives for the final product is contingent upon the completion of several tasks for the initial effort. Those tasks related to the DIS TOOL taxonomy of human performance are discussed below; while, tasks related to the CGF decision taxonomy are discussed in Weaver and Mullen (in preparation).

A. Immediate Tasks Requiring Further Development

Complete the link of missions and CCFs to taxonomy. The development of any taxonomy requires the specification of the boundary conditions for the problem space in which the taxonomy will be developed. The boundary conditions for DIS TOOL are mission, CCFs, and unit organization. For the initial effort, two missions, Deliberate Attack and Hasty Defense, were selected. These mission encompass a broad range of CCFs as well as represent typical tactical situations that can be supported in DIS.

To further constrain the problem space, three CCFS were selected for the initial analysis, CCF 6 (Engage Enemy with Direct Fire and Maneuver), CCF 25 (Provide Operations Security), and CCFs 16/17 (Take Active/Passive Air Defense Measures). Through these three CCFs, other CCFs such as CCF 23 (Provide Countermobility) and CCF 5 (Conduct Tactical Movement) were also to be explored. For analysis purposes, the focus was to be on battlefield activities surrounding an engagement area for the defensive mission. This focus was believed to allow for specification of tasks from battalion through individual soldier. As part of the current development effort, CCF activities were linked to perceptual, cognitive, and motor processes and drove the specification of the remaining taxonomy components, but additional development and refinement is required.

Within this problem space, a list of doctrinal references and source materials should be

used for analysis. The CATT database should provide the necessary references for these sources. These sources will be organized into a matrix linking echelon to doctrinal sources. The purpose of this matrix is to guide analysis and specification of subtasks, decisions, actions, and variables. This matrix will be particularly important in yielding sources for identifying tasks at echelons not currently specified in the CCFs (i.e., below platoon), and for informing the process of variable identification for tasks contained in the CCFs.

Further involve community advocates. The initial multiple taxonomies come from the need of the DIS TOOL to serve a variety of communities. However, it is recognized that the optimum taxonomy would be a single taxonomy which would serve each of the communities equally well. Since it is simply too difficult for the analyst to continually keep in mind the needs of potential user communities during the development process, advocates from five primary communities: combat development, training development, CGF development, materiel development, and test/evaluation were appointed. Using an inductive approach, these advocates need to be closely aligned with the analysts and participate substantially in brainstorming sessions regarding the development of the community-specific aspects of the taxonomy. The advocate will serve as the voice and eyes of their respective community and would provide/collect input focused on the identification of issues where DIS is or might be used, the type of analysis issues that normally are addressed, the variables of interest, and some examples of measures that might or would be used. Finally, the community advocates would review the draft taxonomy, make final inputs, and be responsible for determining the face validity of the taxonomy from the perspective of their user community.

Complete specification of performance dimensions. Based on the linkage of mission and CCFs to the taxonomy and guided by community advocate input, the remaining performance dimensions and associated indicators of performance must be specified. Variable definitions should be derived using both an empirical and community approach. The empirical approach will use selected data (Take Home Packages, Replays, Videos of the After Action Reviews) from the NTC Archive and will center on analyzing different points in the battle to determine what performance dimensions or variables are important. Specifically, the advocates will look at different players at all echelon levels to determine what is important to their performance both in terms of queuing as well as assessing. In addition, this process will allow for "validation" of the analysis performed through the brainstorming sessions. That is, if the initial taxonomy does not include performance dimensions necessary to understand the NTC results then it needs to be modified or expanded. In addition to NTC data sources, test plans from the Director of Combat Development (DCD) at Fort Knox, and Lessons Learned information from Fort Leavenworth may also be accessed and reviewed. The purpose in each case is to help specify variables of interest and concern, and to help identify modifications or expansions to the working model of the taxonomy.

The results of the empirical analysis will provide input to the community analysis. In addition, paper-based demonstrations should be conducted to elicit SME input and review. This process will allow for iterative revisions and improvements and should result in a taxonomy with variable specification for the CCFs under analysis and a methodology for defining variables for the remaining CCFs.

B. Final Taxonomy Tasks

Document taxonomy methodologies. A report which will serve as the blueprint for the completion of the taxonomy must be written. The report must lay out the methodologies necessary to expand the analysis to other missions, CCFs, and echelons; and it must describe the methodologies for combining the separate taxonomic approaches. It must also address the process of identifying performance dimensions and measure specifications. In this regard, it will provide procedures for identifying clusters of tasks that share measurement commonalities such that variables or measures that apply to one task might be assumed to apply to all tasks. Thus, tasks that involve a certain type of decision or that employ a specific behavior such as firing of a weapon would be identified and clustered for measurement purposes. Finally, the report must describe how the taxonomy can be continuously expanded through its use. That is, DIS TOOL users should have the capability to add performance dimensions, measure categories, and indicators of performance to the taxonomy.

Develop DIS TOOL software system. Because the final methodologies adopted for completing the DIS TOOL taxonomy will drive the software system to a certain extent, these two tasks should be completed in parallel. The product of the DIS TOOL software development effort should be a windows-based automated aid that will be useful to a wide variety of Army professionals working in the DIS environment. The DIS TOOL will provide an interactive 3D interface that allows structured query of DIS database variables. At a technical level, the DIS TOOL will be an event-based, object-oriented program that is unified by two major structures: a) a graphic user's interface; and 2) a DIS database metastructure. For a more complete description of the tasks involved in developing the DIS TOOL software system, see BDM Federal (1993). However, the following subtasks organize the primary activities perceived as being involved in the development of the software system:

- Specify User Requirements
- Formulate System Specifications
- Develop Software Preliminary Design
- Develop Detailed Software Design
- Develop Software Code
- Develop System Documentation

Demonstrate DIS TOOL. An area selected for major importance to the combat development and training communities should be selected for the demonstration effort. Included in the demonstration will be a complete taxonomy down to the measure level for the selected topic. Supporting the demonstration will be a briefing describing use of the tool and its advantages. The result of this software demonstration will be proof of the utility of the taxonomy to assess unit performance and control CGFs.

Provide final documentation of effort. A final report should be prepared describing the taxonomy, its development, results of the demonstration, and examples of how it could be further applied to performance measurement and CGF development.

Monitor actual use of DIS TOOL and revise accordingly. The use of DIS TOOL by a variety of DIS users should be evaluated for a specified period of time to ensure that DIS TOOL is meeting the needs of its users. DIS TOOL users should be interviewed and recommendations for further development/improvements should be evaluated by the respective community advocates and analysts, allowing for feedback to be incorporated into the system in a timely manner. This approach is a key aspect of the iterative development process and is viewed as critical to the successful development and implementation DIS TOOL.

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[1]Unpublished references may be obtained by contacting the authors and/or the preparing agency.

VI. Appendix

DIS TOOL Taxonomy

DIS TOOL Taxonomy Measure Category Definitions

ACCURACY	The extent to which misperception of a stimulus event or information content results in an incorrect response.
TIMELINESS	The extent to which reaction time to a stimulus is optimal with regard to METT-T, SALUTE (size, activity, location, unit, time, equipment, and 5 Ws + H (who, what, when, where, why, & how).
FREQUENCY	The number of times a particular behavior occurs.
OPERATIONAL PERSPECTIVE	The extent to which information is accurately placed within the context of friendly/enemy force operations. Includes information concerning areas of operations; areas of interest; time/phasing/duration of the operation; missions of higher, lower, or adjacent units; unit contingency plans in place or in development; friendly capabilities related to operations; enemy capabilities related to operations.

PERCEPTUAL PROCESSES

COLLECT BATTLEFIELD INFORMATION

CANDIDATE ACTIVITIES:	Conduct air/ground watch, receive early warning signals, focus/visualize the battlefield
ERROR SOURCES:	Sensitivity, focus
PERFORMANCE DIMENSION:	Detection
MEASURE CATEGORY:	Accuracy
POTENTIAL INDICATOR:	Percent of OPFOR detected
MEASURE CATEGORY:	Timeliness
POTENTIAL INDICATOR:	Time to detect OPFOR
MEASURE CATEGORY:	Frequency
POTENTIAL INDICATOR:	Number of air-ground attack requests
MEASURE CATEGORY:	Operational Perspective
POTENTIAL INDICATOR:	Were early warning signals adequately responded to?
PERFORMANCE DIMENSION:	Situational Awareness
MEASURE CATEGORY:	Accuracy
POTENTIAL INDICATOR:	Percent of Calls For Fire with correct enemy type
MEASURE CATEGORY:	Timeliness
POTENTIAL INDICATOR:	Mean time out of sector/misoriented
MEASURE CATEGORY:	Frequency
POTENTIAL INDICATOR:	Number of lases to friendly vehicles
MEASURE CATEGORY:	Operational Perspective
POTENTIAL INDICATOR:	Did indirect fire planning keep pace with changes in METT-T?

COGNITIVE PROCESSES

CONDUCT ANALYSIS AND PRE-PLANNING

CANDIDATE ACTIVITIES: Evaluate/integrate/develop/prepare information, plan for combat operations, direct and lead unit during preparation for the battle

ERROR SOURCES: Interpretation, integration, sequence, logic, reconceptualization, association, conception, prioritization, focus, recognition, reaction, testing

PERFORMANCE DIMENSION: Analysis

MEASURE CATEGORY: Accuracy
POTENTIAL INDICATOR: Accuracy of IPB Overlays/Templates

MEASURE CATEGORY: Timeliness
POTENTIAL INDICATOR: Time to develop IPB Overlays/Templates

MEASURE CATEGORY: Frequency
POTENTIAL INDICATOR: Number of times IPB Overlays/Templates updated

MEASURE CATEGORY: Operational Perspective
POTENTIAL INDICATOR: Was translation of Brigade OPORD to Commander's planning guidance accurate?

PERFORMANCE DIMENSION: Pre-planning

MEASURE CATEGORY: Accuracy
POTENTIAL INDICATOR: Difference between planned unit dispersion distance and actual dispersion distance

MEASURE CATEGORY: Timeliness
POTENTIAL INDICATOR: Time to develop synchronized OPORD

MEASURE CATEGORY: Frequency
POTENTIAL INDICATOR: Number of rehearsals conducted to reach desired outcome

MEASURE CATEGORY: Operational Perspective
POTENTIAL INDICATOR: Was the OPORD understood by the participants?

COGNITIVE PROCESSES

CONDUCT FINAL PLANNING AND BATTLE MANAGEMENT

CANDIDATE ACTIVITIES: Update Information, Rehearse, Air Watch, Deceive, Synchronize Tactical Operations, Manage Fire Control and Distribution, Integrate Direct Fire with Maneuver, Manage Air Space, Consolidate and Reorganize

ERROR SOURCES: Interpretation, integration, sequence, logic, reconceptualization, association, conception, prioritization, focus, recognition, reaction, testing

PERFORMANCE DIMENSION: Final Planning

MEASURE CATEGORY: Accuracy
POTENTIAL INDICATOR: Accuracy of situational template updates

MEASURE CATEGORY: Timeliness
POTENTIAL INDICATOR: Time from reception of OPORD to REDCON-1

MEASURE CATEGORY: Frequency
POTENTIAL INDICATOR: Number of requests for FRAGO clarification

MEASURE CATEGORY: Operational Perspective
POTENTIAL INDICATOR: Did reconnaissance effort confirm IPB?

PERFORMANCE DIMENSION: Battle Management

MEASURE CATEGORY: Accuracy
POTENTIAL INDICATOR: Loss exchange ratio

MEASURE CATEGORY: Timeliness
POTENTIAL INDICATOR: Time to reach objectives

MEASURE CATEGORY: Frequency
POTENTIAL INDICATOR: Number of counterattacking companies engaging OPFOR

MEASURE CATEGORY: Operational Perspective
POTENTIAL INDICATOR: To what extent did the Battalion meet the Brigade Commander's intent?

COGNITIVE PROCESSES

SEND, RECEIVE, DISSEMINATE INFORMATION

CANDIDATE ACTIVITIES:	Send\Receive\Disseminate intelligence and battlefield reports, Manage Information
ERROR SOURCES:	INTERPRETATION, INTEGRATION, ASSOCIATION, CONCEPTION, PRIORITIZATION, FOCUS, RECOGNITION
PERFORMANCE DIMENSION:	Receive and Transmit Information
MEASURE CATEGORY:	Accuracy
POTENTIAL INDICATOR:	Consistency of relayed INTEL reports
MEASURE CATEGORY:	Timeliness
POTENTIAL INDICATOR:	Elapsed time from artillery impact to receipt of SHELL report by PLT LDR/CO CDR/BN TOC.
MEASURE CATEGORY:	Frequency
POTENTIAL INDICATOR:	Number of reports transmitted, by report type
MEASURE CATEGORY:	Operational Perspective
POTENTIAL INDICATOR:	How did the reception and transmission of enemy/ friendly information help/hinder the synchronization of tactical operations?
PERFORMANCE DIMENSION:	Workload
MEASURE CATEGORY:	Accuracy
POTENTIAL INDICATOR:	Number of reports transmitted with omitted information, by report type
MEASURE CATEGORY:	Timeliness
POTENTIAL INDICATOR:	Mean time to relay reports by report type
MEASURE CATEGORY:	Frequency
POTENTIAL INDICATOR:	Percent duplicate reports received
MEASURE CATEGORY:	Operational Perspective
POTENTIAL INDICATOR:	How did the management of information affect individual and collective battlefield performance?

MOTOR PROCESSES

MANEUVER, ENGAGE ENEMY, CONTROL TERRAIN

CANDIDATE ACTIVITIES: Control system input; Navigate; Employ direct fire, mortars, field artillery, and close air support; cover and conceal; disperse

ERROR SOURCES: Control, Misinterpretation, Reaction, Location

PERFORMANCE DIMENSION: Simple Motor Responses

MEASURE CATEGORY: Accuracy
POTENTIAL INDICATOR: Distance travelled

MEASURE CATEGORY: Timeliness
POTENTIAL INDICATOR: Mean velocity while moving

MEASURE CATEGORY: Frequency
POTENTIAL INDICATOR: Number of Rounds Fired

MEASURE CATEGORY: Operational Perspective
POTENTIAL INDICATOR: Were troops dispersed in an optimal manner?

PERFORMANCE DIMENSION: Complex Motor Responses

MEASURE CATEGORY: Accuracy
POTENTIAL INDICATOR: Average target counterfire deployment distance

MEASURE CATEGORY: Timeliness
POTENTIAL INDICATOR: Time between threat detection to counterfire

MEASURE CATEGORY: Frequency
POTENTIAL INDICATOR: Percent of firing opportunities taken

MEASURE CATEGORY: Operational Perspective
POTENTIAL INDICATOR: Were direct fires optimally integrated with maneuvers?

COGNITIVE PROCESSES

SEND, RECEIVE, DISSEMINATE INFORMATION

CANDIDATE ACTIVITIES:	Send\Receive\Disseminate intelligence and battlefield reports, Manage Information
ERROR SOURCES:	INTERPRETATION, INTEGRATION, ASSOCIATION, CONCEPTION, PRIORITIZATION, FOCUS, RECOGNITION
PERFORMANCE DIMENSION:	Receive and Transmit Information
MEASURE CATEGORY:	Accuracy
POTENTIAL INDICATOR:	Consistency of relayed INTEL reports
MEASURE CATEGORY:	Timeliness
POTENTIAL INDICATOR:	Elapsed time from artillery impact to receipt of SHELL report by PLT LDR/CO CDR/BN TOC.
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POTENTIAL INDICATOR:	Number of reports transmitted with omitted information, by report type
MEASURE CATEGORY:	Timeliness
POTENTIAL INDICATOR:	Mean time to relay reports by report type
MEASURE CATEGORY:	Frequency
POTENTIAL INDICATOR:	Percent duplicate reports received
MEASURE CATEGORY:	Operational Perspective
POTENTIAL INDICATOR:	How did the management of information affect individual and collective battlefield performance?

MOTOR PROCESSES

MANEUVER, ENGAGE ENEMY, CONTROL TERRAIN

CANDIDATE ACTIVITIES:	Control system input; Navigate; Employ direct fire, mortars, field artillery, and close air support; cover and conceal; disperse
ERROR SOURCES:	Control, Misinterpretation, Reaction, Location
PERFORMANCE DIMENSION:	Simple Motor Responses
MEASURE CATEGORY:	Accuracy
POTENTIAL INDICATOR:	Distance travelled
MEASURE CATEGORY:	Timeliness
POTENTIAL INDICATOR:	Mean velocity while moving
MEASURE CATEGORY:	Frequency
POTENTIAL INDICATOR:	Number of Rounds Fired
MEASURE CATEGORY:	Operational Perspective
POTENTIAL INDICATOR:	Were troops dispersed in an optimal manner?
PERFORMANCE DIMENSION:	Complex Motor Responses
MEASURE CATEGORY:	Accuracy
POTENTIAL INDICATOR:	Average target counterfire deployment distance
MEASURE CATEGORY:	Timeliness
POTENTIAL INDICATOR:	Time between threat detection to counterfire
MEASURE CATEGORY:	Frequency
POTENTIAL INDICATOR:	Percent of firing opportunities taken
MEASURE CATEGORY:	Operational Perspective
POTENTIAL INDICATOR:	Were direct fires optimally integrated with maneuvers?

Appendix B
Briefing Slides for DIS TOOL

Army Research Institute

Overview

Building the Analytic Foundation for DIS TOOL: A Planning Tool for Users of Distributed Interactive Simulation (DIS)

BUILDING THE ANALYTIC FOUNDATION FOR DIS TOOL

TOPICS:

DIS TOOL Overview

- Vision of DIS TOOL
- Benefits of DIS TOOL
- DIS TOOL's linkage to CCF's
- CCF Structure
- DIS Taxonomy

Future Development of DIS TOOL

- Link Missions and CCF's to taxonomy
- Involve community advocates
- Methods
- Specify performance dimensions

Taxonomy Tasks

- Document taxonomy methodologies
- Develop DIS TOOL software system
- Demonstrate DIS TOOL
- Monitor DIS TOOL use and revise accordingly

BUILDING THE ANALYTIC FOUNDATION FOR DIS TOOL
DIS TOOL OVERVIEW

- Vision of DIS TOOL
  - -- Focus on collective performance
  - -- Critical Combat Functions (CCF's) describe collective tasks
  - -- CCF's link collective tasks across echelons
  - -- Linking of different domains that use the same processes, activities, error sources, performance dimensions, measure categories, and/or indicators
  - -- Promote communication amongst user communities
  - -- Develop historical database of measures of performance

BUILDING THE ANALYTIC FOUNDATION FOR DIS TOOL
DIS TOOL OVERVIEW

- Benefits of DIS TOOL
  - -- Performance measures focus on collective tasks
  - -- Economical description of measures of performance (MOPs)
  - -- Increase communication effectiveness among user groups
  - -- Build historical database comprised of measures of performance (MOPs)

BUILDING THE ANALYTIC FOUNDATION FOR DIS TOOL
DIS TOOL OVERVIEW

- DIS TOOLs Linkage to CCF's
  - -- DIS TOOL is highly flexible
  - -- CCF's reflect complex interlocking activities occurring in combat situations
  - -- DIS TOOL in combination with CCF's will organize a wide range of information
- CCF structure
  - -- Describe broad functions associated with combat.
  - -- Consider information categories without being mired in detailed tasks

BUILDING THE ANALYTIC FOUNDATION FOR DIS TOOL
DIS TOOL OVERVIEW

- DIS Taxonomy
  - -- Processes
    - Perceptual
    - Cognitive
    - Motor
  - -- Dimensions
    - Processes
    - Activities
    - Error Sources
    - Performance Dimensions
    - Measure Categories
    - Indicators
    - Value/Utility

BUILDING THE ANALYTIC FOUNDATION FOR DIS TOOL
FUTURE DEVELOPMENT OF DIS TOOL

- Link missions and CCF's to taxonomy
  - -- Boundary conditions
  - -- Mission
  - -- CCF's
  - -- Unit Organization

- Involve community advocates
  - -- Combat Development
  - -- Training Development
  - -- CGF Development
  - -- Materiel Development
  - -- Test/Evaluation

- Methods
  - -- Inductive Approach
  - -- Brainstorm Sessions
  - -- Face Validity for user community

BUILDING THE ANALYTIC FOUNDATION FOR DIS TOOL FUTURE DEVELOPMENT OF DIS TOOL

- Complete Specification of Performance Dimensions

  -- Variable Definitions--Empirical Approach

    - NTC Archive
    - Analyze battles
    - Test plans from Director of Combat Development (DCD)
    - Lessons Learned--Fort Leavenworth

  -- Variable Definitions--Community Approach

    - SME input and review
    - Feedback, revisions, improvements

BUILDING THE ANALYTIC FOUNDATION FOR DIS TOOL TAXONOMY TASKS

- Document taxonomy methodologies
  - -- Methodologies to expand analysis to other missions, CCF's and echelons
  - -- Combine separate taxonomic approaches
  - -- Identify performance dimensions and measure specifications
  - -- Combine tasks for measurement purposes
  - -- DIS TOOL will add to the taxonomy
    - Performance dimensions
    - Measure categories
    - Indicators of performance

BUILDING THE ANALYTIC FOUNDATION FOR DIS TOOL TAXONOMY TASKS

- Develop DIS TOOL software system
  - -- Product: Windows based automated aid
  - -- Event based, object oriented program
    - Graphic user's interface
    - DIS database metastructure
  - -- Subtasks:
    - Specify User Requests
    - Formulate System Specifications
    - Develop Software preliminary design
    - Develop Detailed Software design
    - Develop Software Code
    - Develop System documentation

BUILDING THE ANALYTIC FOUNDATION FOR DIS TOOL TAXONOMY TASKS

- Demonstrate DIS TOOL
  - -- Select area of importance to combat development and training communities
  - -- Prove utility of taxonomy
- Monitor DIS TOOL use and revise accordingly
  - -- Evaluate for specified period of time
  - -- Ensure DIS TOOL meets user's needs
  - -- Conduct feedback sessions with DIS TOOL users
  - -- Allow for timely incorporation of feedback